"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor of Electrical Engineering
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THE DEVELOPMENT OF EMBEDDED NEGATIVE INPUT SHAPING FOR VIBRATION CONTROL OF A FLEXIBLE MANIPULATOR BY USING PIC CONTROLLER

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Hons.)
(Control and Instrumentation)

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NOVEMBER 2009

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DEDICATION

Specially dedicated to
My beloved parents, brothers
and all of my best friends

ACKNOWLEDGEMENT

In preparing this thesis, I was indebted to my supervisor Mr. Mohd Ashraf Bin Ahmad for his guidance and advices throughout my project. Thank you.

Next, I would like to special thank to my family because they had given their caring and supports during my four years study in Universiti Malaysia Pahang.

Besides that, I also appreciate all of the FKEE staffs that they had given their help, critics and suggestions due to my project. For sure, many friends around me also had provided their suggestions and opinions. Thank you all.

Lastly, I want to thank those all who help me directly or indirectly in my completion of final year project.

ABSTRACT

Negative input shaping is one of the techniques used to reduce residual vibration in the flexible manipulator system. An unshaped bang-bang torque input is used to determine the characteristic parameters of the system. The results of response of the manipulator to the shaped inputs are presented in time and frequency domains. But there is a challenging problem exists in the manipulator system because it is difficult to maintain the accurate positioning. To overcome this problem, feed-forward control will consider as the vibration control schemes. Feed-forward involved the control inputs depend on the physical and vibration properties of the system. This technique is more advantage since there are no additional sensors and actuators needed. Results from negative input shaping will show the response of manipulator system has reduced in level of vibration. It is proved that when increase the number of impulses of the specified negative amplitude (SNA) shapers, the level of vibration reduction also increase. There are three specified negative amplitude shapers used in the system. From first order impulse, it has SNA Zero Vibration (ZV), Zero Vibration Derivative (ZVD) and Zero Vibration Derivative Derivative (ZVDD).

ABSTRAK

Input negatif membentuk adalah salah satu teknik untuk mengurangkan getaran sisa pada sistem manipulator fleksibel. Sebuah bang-bang unshaped input torsi digunakan untuk menentukan parameter karakteristik dari sistem. Keputusan respon daripada manipulator ke input berbentuk akan direkod dalam masa dan frekuensi domain. Tapi ada masalah yang mencabar ada di sistem manipulator kerana sukar untuk menentukan kedudukan yang tepat. Untuk mengatasi masalah ini, umpan maju dan kawalan umpan balik akan mempertimbangkan skim kawalan getaran. Feed-maju melibatkan input kawalan bergantung pada sifat fizikal dan getaran daripada sistem. Kelebihan teknik ini ialah kerana sensor dan aktuator tidak diperlukan. Keputusan daripada input negatif membentuk akan menunjukkan respon sistem manipulator telah berkurangan pada kadar getaran. Hal ini terbukti bahawa ketika meningkatkan bilangan impuls tertentu amplitud negatif (SNA) pembentuk, kadar penurunan getaran juga meningkat. Ada tiga pembentuk amplitud negatif digunakan dalam sistem. Pertama ialah SNA SifarGetaran (ZV), Sifar Getaran Derivatif (ZVD) dan Sifar Getaran Derivatif Derivatif (ZVDD).

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LIST OF ABBREVIATIONS

MIMO	Multiple Input Multiple Output
PIC	Peripheral Interface Controller
UM	Unity Magnitude
SNA	Specified Negative Input
ZV	Zero Vibration
ZVD	Zero Vibration Derivative
ZVDD	Zero Vibration Derivative Derivative
LQR	Linear Quadratic Regulator
FTDI	Future Technology Device International
USB	Universal Serial Bus
EEPROM	Electrically Erasable Programmable Read Only Memory
CBUS	Protocol
MCU	Microcontroller Unit
FPGA	Field Programmable Gate Array
UART	Universal Asynchronous Receiver/Transmitter
I/O	Input and Output
VID	Vendor ID
PID	Product ID
LDO	Low Drop Out
NRZI	Non-Return Zero Inverted
SIE	Serial Interface Engine
FIFO	First In First Out
TX	Transmitting signal
RX	Receiving signal
ICSP	In-circuit Serial Programming
PCS	Printed Circuit Board

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This project is discussed about the technique of negative input shaping on vibration control of the flexible manipulator. For this project, the flexible manipulator is designed in formulated model and program to MATLAB software. According the simulation of the software, the transfer function of flexible manipulator is programmed in design. Then run the simulation to verify the results of the system by inject the bang-bang input signal. By analyze the results, the vibration of the manipulator system can be said successful reduced.

1.2 Objective

The main objective of this project is to develop negative input shaping for the vibration control in the flexible manipulator. Control technology of linear systems is a mature discipline with many excellent texts and journals devoted to the topic. Control method can be split into three categories which are single input, single output frequency domain methods (classical control), and multiple output (MIMO) control (focused on time domain control). [1]

1.3 Project Scope

From this project, there are some scopes had been covered to understand clearly about every task that needed to explore as well.

Firstly, the model of the flexible manipulator is program into formulated model by using MATLAB software. By implement the suitable transfer function to design the model of manipulator system, then it is necessary to perform the testing and analysis on the system by inject the bang-bang input.

Secondly, the negative input shapers are separated to three derivative orders. The first order will has two of time interval. The next order will increase in time interval to five and seven of time interval for third order. This will enable users to differentiate those negative input shapers easily.

The simulation studies included all the variables such as frequency of the vibration and distance motion on the system. These results are verified through the MATLAB simulation.

Finally, the PIC controller is connected to the manipulator system to ease users control it effective. The PIC controller can be program by interface between computers easily.

1.4 Problem Statement

In this project, there are some challenging problems such as difficult to maintain the stability of the manipulator system, the complexity aspects of the system and hard to obtain the accurate model of system.

These kinds of problems may occur in the design of manipulator system. The only method to overcome it must develop the input control through the physical properties in the system.

There is another advantage of develop the input control onto the system which because this technique does not require sensors or actuators during designation model of the manipulator system this will lead to reduce the vibration of the manipulator robot.

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